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11.1 INTRODUCTION

11.1.1 Background

Figure 11-1 shows the flash card for Building Block 2.1, Raise State Highways and Place on Piers (Similar to I-80 Across Yolo Bypass).

State Route (SR) 4, SR 12, and SR 160 are the primary local and regional surface transportation corridors in the Sacramento–San Joaquin River Delta (Delta). SR 4, an east-west highway that connects Discovery Bay and Stockton and traverses low-lying areas within the Delta, including Victoria Island, Middle Roberts Island, and Drexler Tract. SR 12, an east-west highway that connects Rio Vista and Lodi, also traverses low-lying areas within the Delta, including Brannan-Andrus Island, Bouldin Island, and Terminous Tract. SR 160, a north-south highway connecting Antioch and Sacramento, consists primarily of levee roads along the Sacramento River. At the southern end of SR 160 in the Delta, the highway leaves the levee and runs at grade (below sea level) across Sherman Island to connect to the Antioch Bridge. At the northern end of SR 160 in the Delta, the highway leaves the levee and runs at grade through the Sacramento urban area known as the “Pocket Area.”

SR 4, SR 12, and the Sherman Island portion of SR 160 are susceptible to flooding in the event of levee failure and island flooding. The levee crest portion of SR 160 is also susceptible to damage in the event of a levee breach (due to any event), damage due to erosion after an island is flooded (as a result of wind-wave action), and earthquake damage, because most of the levees on which the highway is built are not seismically resistant. This issue is further discussed in Section 4, Building Block 1.2, Upgraded Delta Levees.

11.1.2 Purpose and Scope of Building Block

Raising SR 4, SR 12, and SR 160 above the Federal Emergency Management Agency (FEMA) 100-year flood elevation and constructing them on piers with a seismically resistant design can reduce the risk of damage and failure for these highways. The purpose of Building Block 2.1 is to evaluate the feasibility of this risk-reduction option. The conceptual cost estimate that is prepared as part of this building block is based on a typical cross section of the new, elevated structure. Constructability considerations are discussed in Section 11.3.3. The availability and sources of the construction materials required for this building block are also evaluated. Because of the conceptual nature of the study, the building block does not evaluate the following aspects of the proposed improvement:

- Local access to the new elevated structures
- Future expansion plans for these state highways

11.1.3 Objective and Approach

The primary objectives of this building block are to do as follows:

- Reduce the risk of potential loss of usability of SR 4, SR 12, and SR 160 due to flooding and earthquake damage.

- Provide for uninterrupted operation of these transportation corridors for emergency evacuation and response and movement of emergency response materials. When the emergency is stabilized, the availability of these state highways for normal use is also desired as repairs continue.

Using aerial photographs and information from the Geographic Information System (GIS) database specifically prepared for the Delta Risk Management Strategy (DRMS) project, conceptual horizontal and vertical alignments were developed for each of the three state highways. More accurate topographic mapping of the Delta was not available at the time of this analysis.

11.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

11.2.1 Analysis Criteria and Basis of Design

The limits of improvement on SR 4 and SR 12 are determined by comparing the FEMA 100-year flood elevations with the ground elevations along the existing highway alignments (Figure 11-2). The preliminary elevation data from the GIS database indicate that the majority of existing bridges across various waterways along both SR 4 and SR 12 are above the FEMA flood elevation. This finding is further confirmed by the common bridge design criterion that a freeboard above a certain established flood elevation is required to set a bridge's soffit elevation. Therefore, for the purpose of this analysis, it is assumed that no existing bridges on SR 4 and SR 12 need to be raised or modified.

The limits of improvement on SR 160 are between the northern approach to the Antioch Bridge over the San Joaquin River and the terminus of SR 160 at the southern Sacramento city limit (Figure 11-3). Because the existing alignment of SR 160 follows the circuitous Sacramento River, a more direct alignment for a new, elevated SR 160 was evaluated. This new alignment is further discussed in Section 11.2.2.

The Yolo Causeway, the portion of Interstate 80 (I-80) across the Yolo Bypass to the west of Sacramento, was used as the basis for design. I-80 carries six lanes of traffic (three in each direction) across the Yolo Bypass (Figure 11-4). A series of concrete piers, spaced on average every 50 feet on center, support the concrete deck. Similar to the Yolo Causeway, the superstructure of the proposed elevated highways will consist of pre-cast, pre-stressed (PC/PS) single- and double-stemmed concrete girders with spans of up to 50 feet supported on concrete piers (Figure 11-5). The advantages of the proposed superstructure are:

- Each span can be prefabricated off-site (which results in fewer impacts to the surrounding environment)
- No bridge false work is necessary during construction
- Pre-cast concrete construction is generally faster than cast-in-place concrete construction

The substructure will include cast-in-place concrete piers at each 50-foot interval, similar to those supporting the Yolo Causeway. The foundation for each pier will consist of driven concrete piles with a cast-in-place pile cap. Preliminary subsurface soil data show that driven piles will be needed to pass through the peat layer and loose sand that exist within the Delta. The estimated pile embedment below the peat layer is 40 feet.

11.2.2 Analysis Results and Design Layouts

11.2.2.1 SR 4 and SR 12

Utilizing the criteria described in Section 11.2.1, about 18.4 miles of SR 4 and about 15.0 miles of SR 12 will need to be elevated. The limits of the improvement on SR 4 are between the Byron Highway/SR 4 junction and the Interstate 5 (I-5)/SR 4 junction. The limits of the improvement on SR 12 are between the Rio Vista Bridge and the I-5/SR 12 junction.

As described in Section 11.2.1, the existing bridge structures located along both highways within the project limits are assumed to remain and not to need modifications (except for the approaches). Should some of these bridges be determined to require replacement, the cost would be an additional cost not addressed in this analysis. The new elevated structures would be constructed in parallel with and adjacent to the existing highways.

Land acquisition along one side of the existing roadways would be necessary for the proposed improvements.

11.2.2.2 SR 160

The new alignment of SR 160 begins to deviate from the existing alignment at the northwestern corner of Brannan-Andrus Island. At this location, a new drawbridge across the Sacramento River, with a span of approximately 1,000 feet, would be needed to maintain the navigability of the river. The new drawbridge would be similar to the ones currently in use in the Delta (Figure 11-6). The alignment then proceeds in a northeasterly direction and crosses Steamboat Slough with another new 800-foot-long drawbridge. The alignment stays on the west bank of Sutter and Elk sloughs, traverses Ryer Island and the Netherlands district, and eventually conforms to the existing SR 160 at the Freeport Bridge over the Sacramento River, in the town of Freeport.

The total length of the new, more direct alignment of SR 160 is about 33.3 miles, which is roughly 40 percent shorter than the existing alignment. A conceptual layout of this alignment is shown on Figure 11-3. Land acquisition along the new alignment would be necessary.

11.2.3 Geometric Description of Improvement

Because SR 4, SR 12, and SR 160 are two-lane highways, the width of the proposed elevated structures is assumed to be 40 feet. This width allows two 12-foot-wide travel lanes with two 8-foot-wide shoulders.

The structural depth, the dimension measured from the top of bridge deck to the bottom of girder (soffit), is assumed to be 4 feet. A freeboard of 3 feet above the 100-year FEMA flood elevation will be used. The flood elevation along SR 4 and SR 12 is roughly 10 feet, so the deck elevation of the new SR 4 and SR 12 would be at roughly 17 feet. In the case of SR 160, the deck elevation would range from 17 to 30 feet due to various flood elevations along the roadway alignment.

11.2.4 Description of Values, Benefits, and Constraints

As discussed in Section 11.1.2, the main benefit of constructing SR 4, SR 12, and SR 160 on elevated structures is to reduce the risk of losing these important transportation corridors after a major flood or earthquake. Preservation of these highways would allow the movement of freight and emergency supplies in the critical period immediately after such an event. Also, trips designed to go through the Delta would not be forced to detour around the Delta.

Potential constraints to the proposed improvements in Building Block 2.1 include:

- Fewer points of local access to the elevated highways: The new elevated highways would likely have fewer access points (entrances and exits) compared to the existing highways due to the high cost of constructing on- and off-ramps.
- The conceptual alignments of SR 4, SR 12, and SR 160 need further study and refinement once more accurate topographic mapping is available. Land acquisition issues and environmental regulations may also constrain the location of the new highways.
- It may be impractical to allow both the new elevated highways and the existing highways to use the same bridges throughout the Delta. Also, one or more of the existing bridges may be determined to be obsolete or to have an unusable alignment for the raised highway.

11.3 COST ESTIMATE

11.3.1 Quantities

The following list shows the number of miles of new elevated highway and the number of feet of new drawbridge proposed under Building Block 2.1:

Highway	Length of New Elevated Highway (miles)	Length of New Drawbridge (feet)
SR 4	18.4	-
SR 12	15.0	-
SR 160	33.3	2,100

11.3.2 Material Source Analysis

PC/PS concrete girders for the elevated highway can be obtained from Antioch, in Contra Costa County, or Petaluma, in Sonoma County. If the PC/PS concrete structures are not available at these sources, they can be obtained from other sources with longer haul distances.

11.3.3 Construction Considerations

For SR 4 and SR 12, the existing highways may be used for construction access and the shoulder may be used as a laydown area for the contractor. A temporary gravel-surface access road may be needed for footing construction and pile driving. Cranes would be needed to lift and position the precast concrete girders onto the cast-in-place concrete piers. The existing highway shoulders could be used as a staging area for the contractors. K-rails (temporary concrete barriers) may be used as a temporary barrier between the construction zone and the highway traffic. Where the existing roads are too narrow to allow both laydown and two-way traffic, one-way traffic may be necessary during construction. Where the new structures conform to the existing bridges, staged construction and traffic control would be required to maintain existing traffic.

For SR 160, the contractor may have to construct a temporary access road as the first order of work, because no roadway exists along the new alignment of SR 160.

11.3.4 Cost Estimate Tables

11.3.4.1 Capital Cost

As listed in the bridge unit cost data published by Caltrans in 2007 (Appendix 11A), a unit cost of $250 per square foot was used for the elevated structures. Assuming a width of 40 feet, the unit cost of the elevated structures is $52.8 million per mile.

For the proposed new drawbridges, a unit cost of $1,000 per square foot was used. Assuming a width of 40 feet, the unit cost of the drawbridges is $40,000 per foot.

According to 2007 real estate sales data, the average cost of open land is $10,000 per acre. Assuming the width of a new right-of-way for each elevated highway is 80 feet, the cost of land is calculated to be $100,000 per mile of highway.

The estimated costs of this building block are listed in Table 11-1.

11.3.4.2 Operation Cost

No significant operation cost is anticipated for the elevated highway construction. However, periodic repair of the elevated structures is anticipated.

11.4 RISK REDUCTION EVALUATION

11.4.1 Direct Risk Reduction

This building block effectively eliminates the potential adverse consequences for SR 4, SR 12, and SR 160 due to levee failure under present (2007) conditions. This building block also offers the benefit of uninterrupted operation of these transportation corridors for emergency response and normal uses. Some allowance may be necessary to accommodate future conditions (sea-level rise and larger floods). If so, this allowance would entail some increase in costs. If this allowance is inadequate, the raised highways may become vulnerable to periodic flooding in the next 50 to 100 years or more and may need to be raised.

11.4.2 Estimation of Risk Reduction

The avoided direct economic costs and indirect economic impacts of this building block are evaluated in the context of the scenarios in Section 18.

11.5 FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Raising SR 4, SR 12, and SR 160 and constructing them on elevated structures would require significant investment, estimated at $6.1 billion. Such improvement may be feasible, but the cost of the improvement may outweigh the benefit. Also, creating new elevated highways that are two lanes assumes that the current highways have sufficient capacity to handle demand for the foreseeable future. For such a large investment, it would be important to consider expanding capacity at the same time, because future widening of the elevated highways would be considerably more costly.

Despite the high cost and the potentially low risk-reduction benefit of this building block, it is essential to consider the intangible benefits before reaching any conclusions. If a significant number of Delta levees were to be breached, the state highways would serve as access routes for emergency evacuation, response, and repairs. The loss of these highways during an emergency period would lead to delay in repairing damaged levees and, in turn, increase the economic costs. Also, if flooding or an earthquake damaged the railroads, freight movement would have to rely on the state highways, interstates, or detours around the Delta. The inability to use the state highways would result in additional economic costs.

Tables

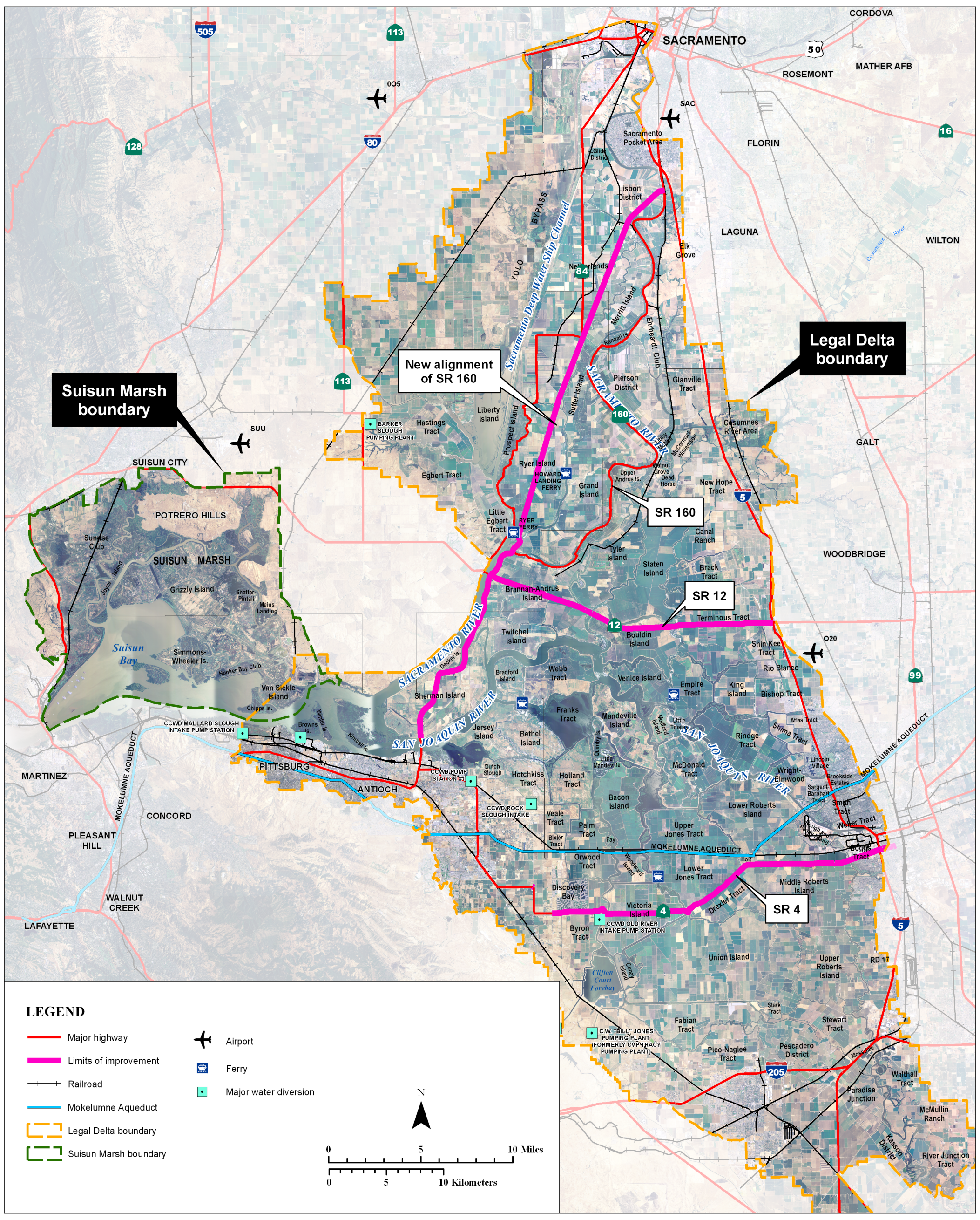
Table 11-1 Summary of Cost Estimates

Cost Items	Cost ($million)		
	SR 4	SR 12	SR 160
Elevated structure	972	792	1,758
Drawbridge	----	----	84
Land	2	2	3
Subtotal	974	794	1,845
Contingency (30%)	292	238	554
Total construction cost	1,266	1,032	2,399
Soft cost* (30%)	380	310	720
Total capital cost	1,646	1,342	3,119
Grand total	6,107		

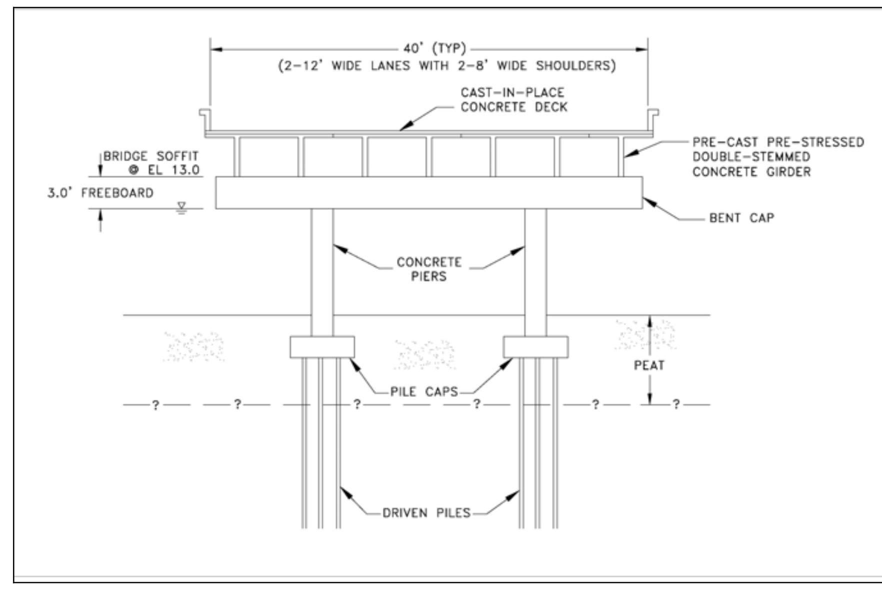
* Soft cost refers to the costs of administration, design/engineering, and construction management.

SR = State Route

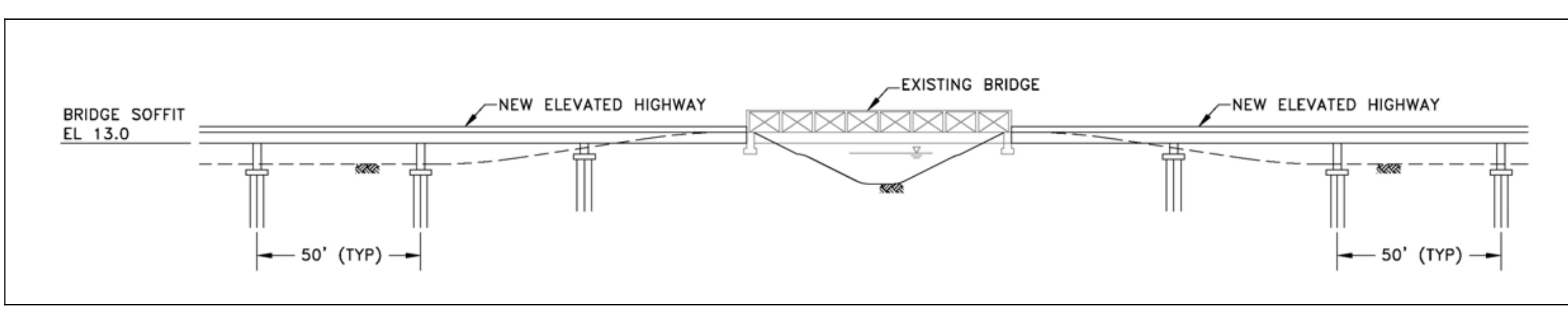
Figures



PLAN



TYPICAL SECTION



TYPICAL ELEVATION

PROJECT FEATURES

Building block proposes to raise SR 4, SR 12 and SR 160 and place them on piers. A typical elevated structure for all three highways will have the following parameters:

- Precast, prestressed double-stemmed concrete girder supported by concrete piers
- Two columns at each pier
- Spacing between piers is 50 feet
- Width of roadway is 40 feet
- Pile foundation
- 3 feet of freeboard over 100-year FEMA flood elevation
- Meets Caltrans Seismic Design Criteria for bridge design

Note: Project costs may be truncated (reduced) when joined with other building blocks in scenarios.

OBJECTIVES AND BENEFITS

- Reduce the risk of potential loss of SR 4, SR 12, and SR 160 due to flooding and earthquake
- Provide for the uninterrupted operation of these transportation corridors for emergency response and normal uses
- Benefits = avoided economic costs due to loss of highway use

PROJECT COSTS

SR 4: Length = 18.4 miles
Capital Cost = $1.7 billion
SR 12: Length = 15.0 miles
Capital Cost = $1.3 billion
SR 160: Length = 33.3 miles
Capital Cost = $3.1 billion

Total Capital Cost = $6.1 billion

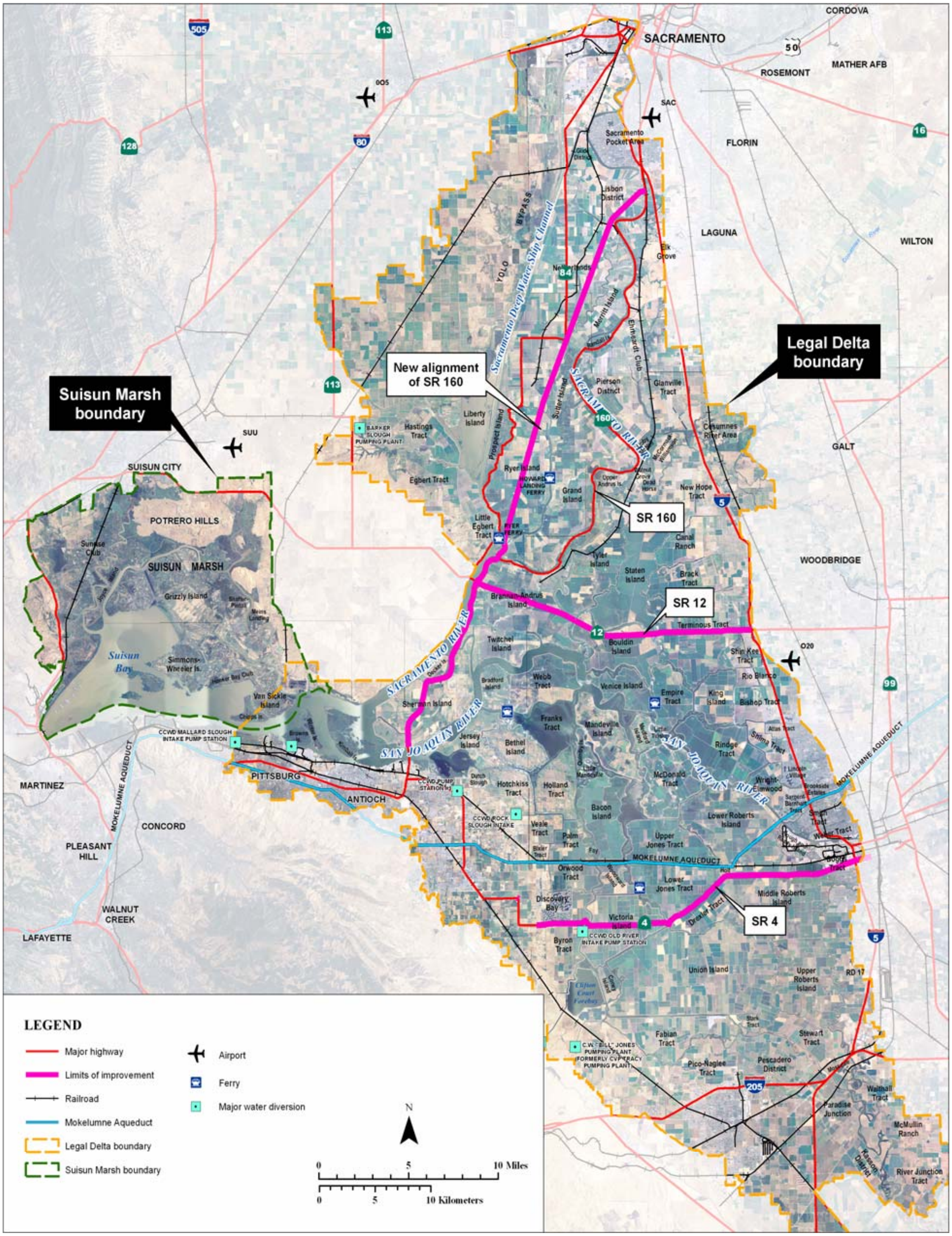


Figure 11-2 Limits of Improvements on SR 4, SR 12, and SR 160

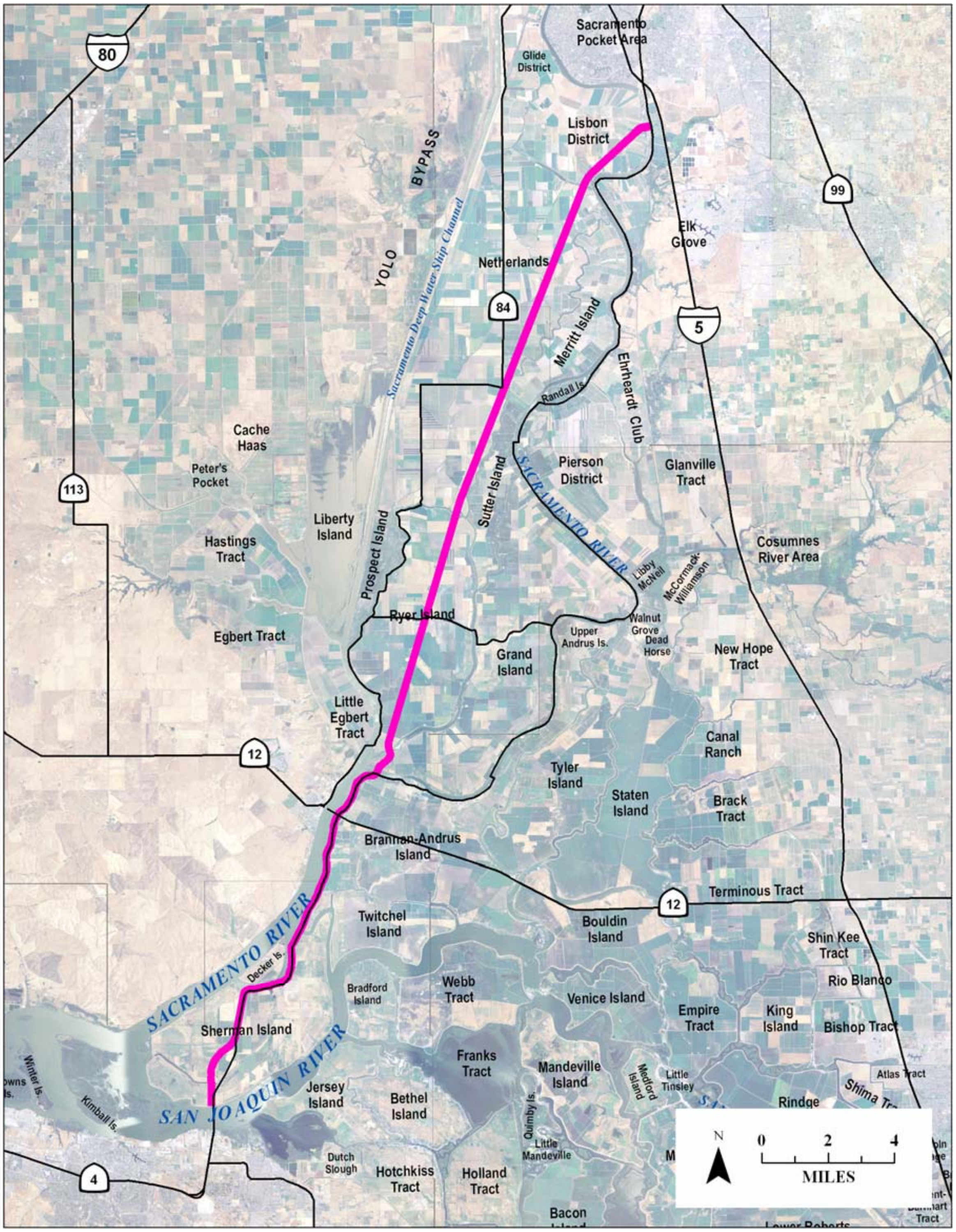


Figure 11-3   Layout of Realigned SR 160

Figure 11-4 Photo of I-80 at Yolo Bypass

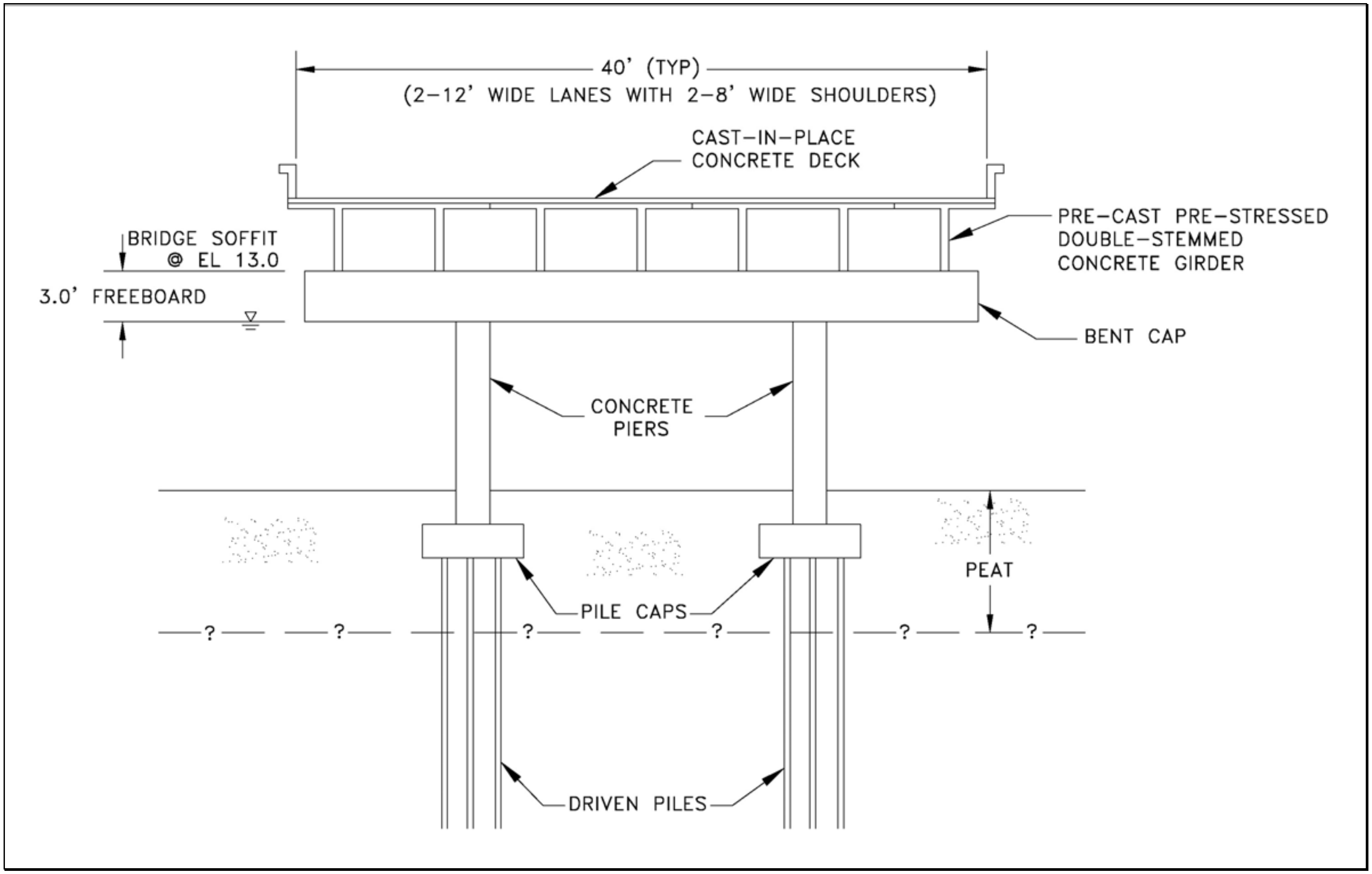


Figure 11-5 Typical Cross Section of the Elevated Structure

Figure 11-6 Photos of Drawbridges in the Sacramento Delta

Appendix 11A

Comparative Bridge Costs

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
DIVISION OF STRUCTURE EARTHQUAKE ENGINEERING & DESIGN SUPPORT
OFFICE OF SPECIFICATIONS & ESTIMATES
P. O. BOX 942874
SACRAMENTO, CA 94274-0001

COMPARATIVE BRIDGE COSTS

JANUARY 2007

The following tabular data gives some **general guidelines** for structure type selection and its relative cost. These costs should be used just for **preliminary estimates** until more detailed information is developed.

These costs reflect the **'bridge cost'** only and ***do not*** include items such as: bridge removal, approach slabs, slope paving, soundwalls or retaining walls.

The following factors *must* be taken into account when determining a price within the cost range:

Factors for Lower end of Price Range	Factors for Higher end of Price Range
Short spans, Low Structure Height, No Environmental Constraints, Large Project, No Aesthetic Issues, Dry Conditions, No Bridge Skew	Long spans, High Structure Height, Environmental Constraints, Small Project, Aesthetic Issues, Wet Conditons (cofferdams required), Skewed Bridges
Urban Location	Remote Location
Seat Abutment	Cantilever Abutment
Spread Footing	Pile Footing
No Stage Construction	2 Stage Construction

Factors that will increase the price over the high end of the Price Range 25%-150%

Structures with more than 2 construction stages
Unique substructure construction
Widenings less than 15 Ft.

STRUCTURAL SECTION	(STR. DEPTH / MAX SPAN)		COMMON SPAN RANGE **feet**	COST RANGE **$ / Square foot**	REMARKS
	SIMPLE	CONTINUOUS			
RC SLAB	0.06	0.045	16 - 44	130 - 210	THESE ARE THE MOST COMMON TYPES AND ACCOUNT FOR ABOUT 80% OF BRIDGES ON CALIFORNIA STATE HIGHWAYS.
RC T-BEAM	0.07	0.065	40 - 60	150 - 275	
RC BOX	0.06	0.055	50 - 120	160 - 270	
CIP/PS SLAB	0.03	0.03	40 - 65	160 - 205	
CIP/PS BOX	0.045	0.04	100 - 250	150 - 230	
PC/PS SLAB	0.03 (+3" AC)	0.03 (+3" AC)	20 - 50	195 - 270	NO FALSEWORK REQUIRED.
PC/PS T, TT, ⊥	0.06 (+3" AC)	0.055 (+3" AC)	30 - 120	200 - 270	
BULB T GIRDER	0.05	0.045	90 - 145	180 - 280	
PC/PS I	0.055	0.05	50 - 120	200 - 260	
PC/PS BOX	0.06	0.045	120 - 200	220 - 395	
STRUCT STEEL I GIRDER	0.045	0.04	60 - 300	240 - 370	NO FALSEWORK REQUIRED.

NOTE: Removal of a box girder structure costs from $15 - $20 per square foot.

COSTS INCLUDE 10% MOBILIZATION